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# Electroretinography and circadian rhythm in *Lycosa tarentula* (Araneae, Lycosidae)

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Electroretinography reveals the existence of a well marked circadian rhythm. Anterior eyes have a high nocturnal sensitivity, whereas posterior eyes have a high diurnal sensitivity.

## 1. Introduction

A few works have been devoted to the visual system of Lycosidae. These researches on very different species were too fragmentary to give a precise idea of the working of the visual system. Among physiological works, the most important are those of Magni et al. (1964, 1965), De Voe et al. (1969) and De Voe (1972). Works on the effect of the visual system on the behaviour of Lycosidae are non-existent except for those of Homann (1931), Gettman (1976), Acosta et al. (1982) and Lizotte & Rovner (1988).

Lycosidae have four pairs of eyes set out in three rows on the frontal and lateral parts of the prosoma. The first row comprises small eyes, the anterior median (AME) and anterior lateral eyes (ALE). The second row is formed by the posterior median eyes (PME), which are large eyes located on the frontal part. The third row is formed by the posterior lateral eyes (PLE), located at the lateral posterior limit of the cephalic region (Figs. 1, 2). According to the usual terminology, the anterior median eyes are the principal eyes, and the three other pairs (ALE, PME, PLE) are called accessory or secondary eyes.

We have undertaken, in *Lycosa tarentula*, a study of the morphology and physiology of the visual system. Here are reported the first electrophysiological results obtained from female *Lycosa tarentula*.

## 2. Material and methods

Adult females of *Lycosa tarentula* were captured around the Madrid Autonomous University. The animals in the experiments of electrophysiology were kept at the laboratory in Paris in individual

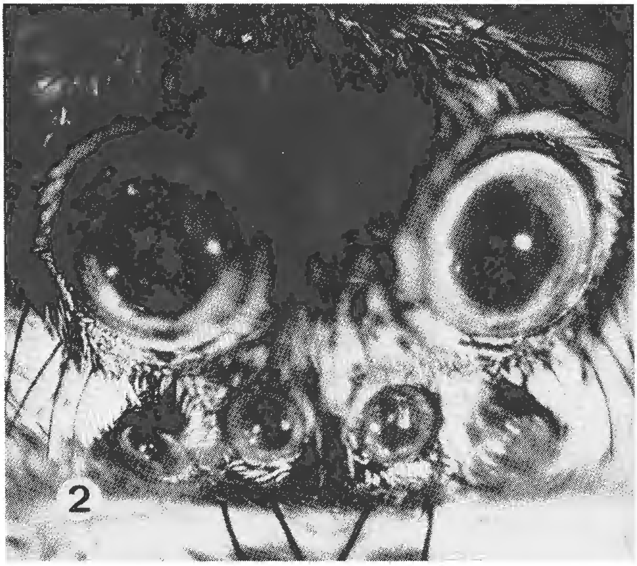


Fig. 1. General view of the eyes of *Lycosa tarentula*. — Fig. 2. Anterior eyes and posterior median eyes of *Lycosa tarentula*.

boxes at a temperature of 20°C and with a normal cycle of light 10h / dark 14h. Most animals weighed between 1300 and 1800 mg.

Three characteristics of the eyes were studied: the electroretinogram (ERG), the frequency transfer function (FTF), and the flicker fusion frequency (FFF). The animals were kept on a stainless steel sheet used as the indifferent electrode; a thin stainless steel wire was located on the eye. The signals elicited between the electrodes were amplified by a solid state high input impedance amplifier and photographed on the screen of a cathode ray oscilloscope (CRO).

For ERG recording, the stimulus was a white electronic flash. For the FTF and the FFF, the stimulus was a white luminous flux, modulated in sinusoidal function by a rotating polaroid. All details of these techniques have been previously published (Carricaburu & Duhazé 1978, Carricaburu & Muñoz-Cuevas 1978).

## 3. Results

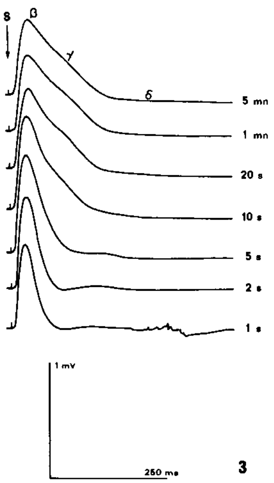
In Arthropods, the ERG in response to an electronic flash is composed of four waves, $\alpha$ positive, $\beta$ and $\gamma$ negative, and $\delta$ positive (Carricaburu & Muñoz-Cuevas 1981). These four waves are not always observed together. As in all Chelicerates previously studied, there are marked differences between day and night ERG.

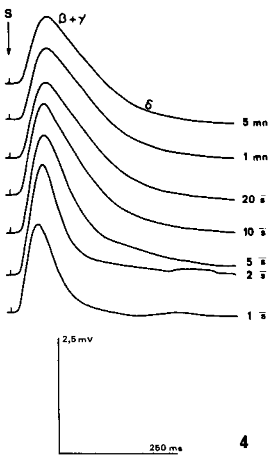
### 3.1. Anterior median eyes

During the day (Fig. 3) the ERGs, after 5 min of dark adaptation, present $\beta$ and $\gamma$ waves and very small $\delta$ waves. During the night (Fig. 4), $\beta$ and $\gamma$ merge into high amplitude negative waves, and $\delta$ is amplified. The FTF is given in Fig. 5 which shows a distinct decrease of the flicker fusion frequency (FFF) during the night.

### 3.2. Anterior lateral eyes

During the day (Fig. 6), the ERGs resemble those of the anterior median eyes. During the night (Fig. 7) the $\beta$ wave has a very high voltage. The FTF (Fig. 8) is less modified by the circadian rhythm than that of the anterior median eyes.



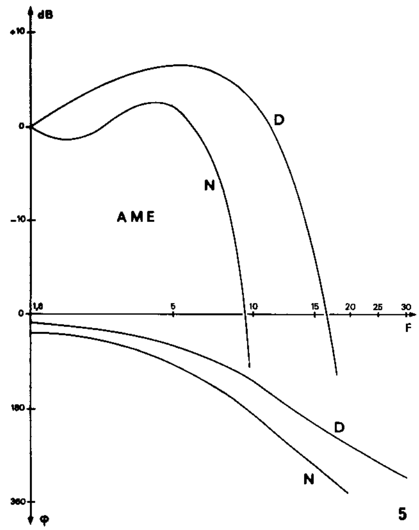
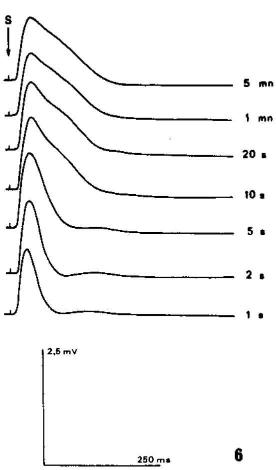
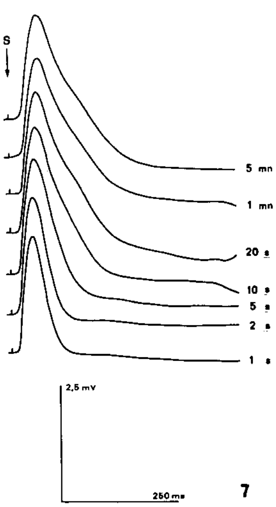




Fig. 3. Diurnal ERGs of the anterior median eye. Curves 1 sec,..., 5 min, dark adaptation 1 sec,..., 5 min. — Fig. 4. Nocturnal ERGs of the anterior median eye. — Fig. 5. FTF of the anterior median eye. D = day, N = night. Upper part = amplitudes in decibels. Lower part = phase shift in degrees.



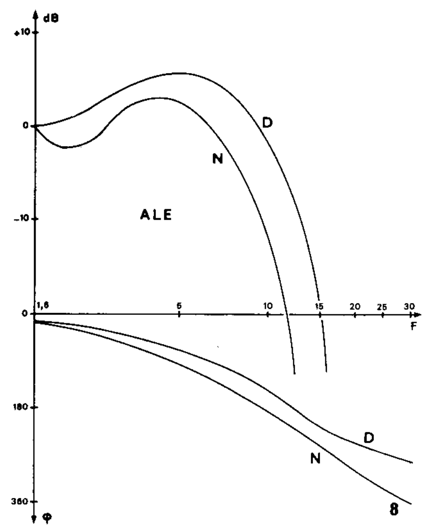
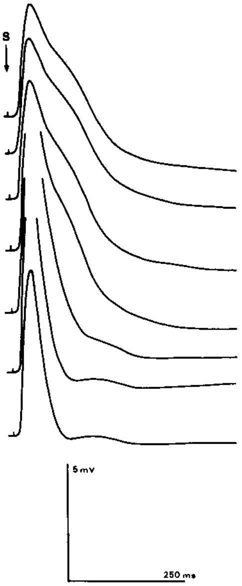




Fig. 6. Diurnal ERGs of the anterior lateral eye. — Fig. 7. Nocturnal ERGs of the anterior lateral eye. — Fig. 8. FTF of the anterior lateral eye.

### 3.3. Posterior median eyes

The amplitude of diurnal ERGs (Fig. 9) reaches three to four times the amplitude of nocturnal ERGs (Fig. 10), even for very short dark-adaptation. $\beta$ and $\gamma$ waves are well-separated during the day, and merge during the night. The positive $\delta$ wave that exists during the day has a high voltage during the night. The circadian rhythm is well-marked in the FTF (Fig. 11).



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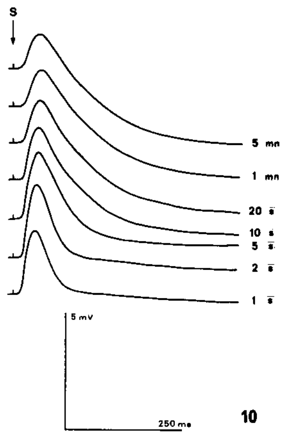

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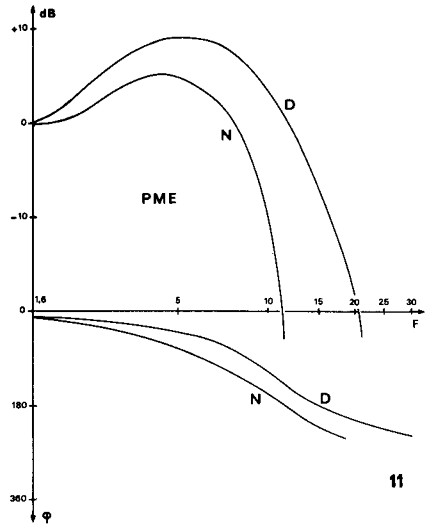

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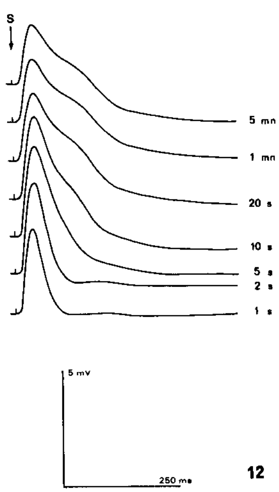
Fig. 9. Diurnal ERGs of the posterior median eye. — Fig. 10. Nocturnal ERGs of the posterior median eye. — Fig. 11. FTF of the posterior median eye.



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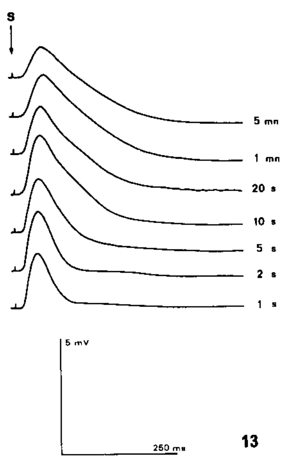

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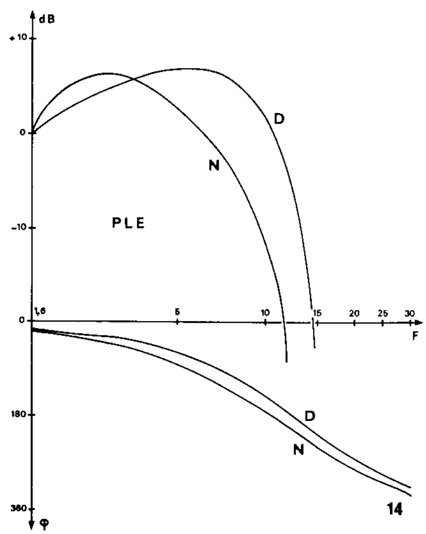

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Fig. 12. Diurnal ERGs of the posterior lateral eye. — Fig. 13. Nocturnal ERGs of the posterior lateral eye. — Fig. 14. FTF of the posterior lateral eye.

### 3.4. Posterior lateral eyes

Diurnal ERGs (Fig. 12) have twice the amplitude of nocturnal ERGs (Fig. 13). During the day, $\beta$, $\gamma$ and $\delta$ waves are marked, but during the night $\beta$ and $\gamma$ merge, and the amplitude of $\delta$ greatly increases. The FFF slightly decreases during the night (Fig. 14).

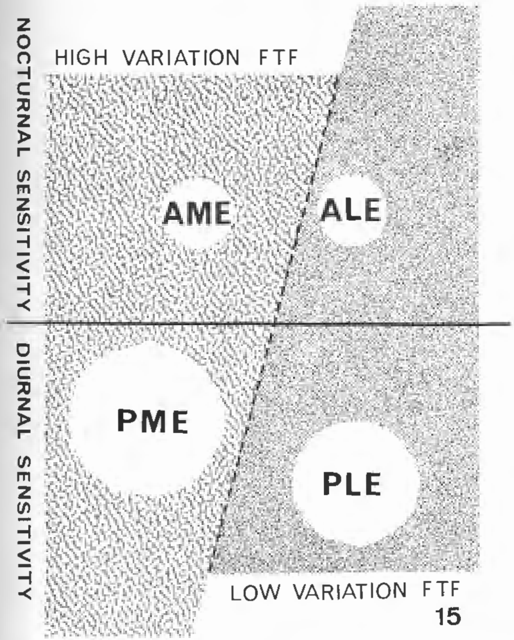


Fig. 15. Circadian functioning of the eyes.

## 4. Discussion

Our experiments show that *Lycosa tarentula* has a circadian rhythm which appeared in the electrophysiological responses of the eyes. Schematically, the anterior eyes have a higher sensitivity during the night than during the day. The first behavioural experiments show that the anterior eyes may control at least a part of the nocturnal activity. The visual system of *Lycosa tarentula* appears to be complex. The four eyes can be grouped into two different sets, according to the characteristics considered. If sensitivity is considered, we have an anterior and a posterior set. On the other hand, if the FFF is considered, we have a median and a lateral set (Fig. 15).

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